

CLAIMS

1                   A method for coating a substrate with an  
inorganic-organic hybrid polymer material using the  
5 Dielectric Barrier Discharge (DBD) technique, said method  
comprising the steps of:

- a)                   introducing a sample in the space between two  
electrodes,
- b)                   controlling the atmosphere between the  
10 electrodes,
- c)                   generating a plasma discharge between the  
electrodes,
- d)                   mixing aerosols containing hybrid  
organic/inorganic cross-linked pre-polymers formed via sol-  
15 gel processing, into the plasma discharge

2.                   A method as claimed in claim 1, in which one  
or more of the following additional components may be added  
to the plasma discharge: gases, vapors, aerosols or powders  
20 of non cross-linked precursor chemicals.

3                   A method as claimed in either preceding claim  
in which the aerosol in step d) comprises a compositional  
gradient of the pre-polymers and/or any additional admixed  
25 components.

4                   A method as claimed in any preceding claim,  
in which the plasma is maintained at a pressure from about  
100Pa to about 1MPa, preferably from about 1 kPa to about  
30 1MPa , more preferably at about atmospheric pressure.

5.                   A method as claimed in any preceding claim,  
wherein the plasma is generated by alternating voltage

between the electrodes of a frequency from about 10Hz to about 50MHz.

6                   A method as claimed in any preceding claim,  
5 wherein the substrate comprises plastic, non-woven or woven fibers, natural, synthetic or semi-synthetic fibers, cellulosic material, metal, ceramic, powder or any composite structure thereof.

10 7                   A method as claimed in any preceding claim,  
wherein the hybrid inorganic-organic coating increases, decreases and/or controls one or more of the following physical properties compared to the uncoated substrate: hydrophilic, hydrophobic, oleophilic, oleophobic, adhesive,  
15 release, gas diffusion barrier, liquid diffusion barrier, solids diffusion barrier, chemical resistance, UV resistance, thermal resistance, flame retardancy, porosity, conductivity, optical, self cleaning, acoustic, roughness, wear resistance, scratch resistance, lubricating,  
20 antimicrobial, biocompatible, sensory, catalytic properties, humidity, drug release, softness to touch, taste, smell, insect repelling properties, allergic reaction, toxicity, acid-base level.

25 8                   A method as claimed in any preceding claim,  
in which the coating is an inorganic-organic hybrid polymer obtained and/or obtainable from an aerosol containing cross-linked inorganic-organic hybrid pre-polymer, formed via sol-gel processing.

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9.                   A method as claimed in any preceding claim,,  
in which the inorganic-organic hybrid pre-polymer is obtained and/or obtainable from one or more of:

Tetramethoxysilane; Tetraethoxysilane; Dynasil 40;  
 Zirconium-tetrapropoxide; Aluminium-tributoxide Titanium-  
 tetraethoxide; Aluminium-dibutoxide ethylacetoacetate;  
 Zirkonium-tripropoxide methylacrylate; Bayresit VPLS 2331 ;  
 5 Propyltrimethoxysilane; ; Phenyltrimethoxysilane;  
 Diphenyldimethoxysilane; Mercaptopropyltrimethoxy-silane;  
 Tridecafluoro-triethoxysilane; Aminopropyltriethoxy-silane;  
 Trimethylammonium-propyltrimethoxysilane;  
 Octadecyldimethylammonium-propyltrimethoxysilane;  
 10 Vinylbenzyl ammoniummethyl aminopropyltrimethoxysilane;  
 Succinic acid anhydride propyl triethoxysilane;  
 Glycidoxypropyl-trimethoxysilane; Vinyltrimethoxy-silane;  
 Methacryloxypropyl-trimethoxysilane; TPGDA-silane; TEGDA-  
 silane; BPADA-silane; LR 8765 silane; GDMA-silane and/or;  
 15 PETA-silane, silylated polymers and/or suitable mixtures  
 thereof.

10 A method as claimed in any preceding claim,  
 where the pre-polymer mixture in step d) further comprises  
 20 - inorganic coating forming materials preferably selected  
 from : colloidal metals, metal oxides, organometallic  
 compounds and/or  
 - organic coating forming materials; preferably selected  
 from : carboxylates, (meth)acrylates, styrenes,  
 25 methacrylonitriles, alkenes and/or dienes, (meth)acrylic  
 acid, fumaric acid (and esters), itaconic acid (and  
 esters), maleic anhydride, halogenated alkenes,  
 (metha)acrylonitrile, ethylene, propylene, allyl amine,  
 vinylidene halides, butadienes, (meth)acrylamide, epoxy  
 30 compounds, styrene oxide, butadiene monoxide,  
 ethyleneglycol diglycidylether, glycidyl methacrylate,  
 bisphenol A diglycidylether (and its oligomers),

vinylcyclohexene oxide and phosphorus-containing compounds and/or any suitable mixtures thereof.

11                   A method as claimed in any preceding claim,  
5   in which the inorganic-organic hybrid coating is obtained  
and/or obtainable by mixing separately in addition to the  
aerosol in step d) one or more additional gases, vapours,  
aerosols or powders of the following compounds to the  
plasma discharge: Ar, He, O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>, CO, SF<sub>6</sub>, NO, NO<sub>2</sub>, N<sub>2</sub>O,  
10 H<sub>2</sub>, methane, ethane, propane, butane, ethylene, propylene,  
ethylene oxide, propylene oxide, acetylene, CF<sub>4</sub>, C<sub>2</sub>F<sub>6</sub>, C<sub>2</sub>F<sub>4</sub>,  
H<sub>2</sub>O and/or any of the ingredients described in claim 10.

12.                   A method as claimed in any preceding claim,  
15   in which the coating is applied as a liquid precursor.

13                   A method as claimed in any preceding claim,  
in which the substrate which is coated is selected from,  
a powder, wire and a moving material web.

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14.                   A coated substrate obtained and/or obtainable  
by a method as claimed in any preceding claim.

15.                   An apparatus for generating and maintaining a  
25   plasma for use in a method as claimed in any of claims 1 to  
13; the apparatus comprising a pair of electrodes, a gap  
being present between said electrodes, and a voltage  
generator for applying a voltage between said electrodes,  
said electrodes consisting of an electrically conducting  
30   material, wherein one or both electrodes are covered with  
an electrically insulating material, and where the  
generator is capable of generating an alternating voltage a  
frequency from about 10Hz to about 50 MHz.

16. The apparatus according to claim 15, where said electrodes have the form of planar or curved plates or grids, bars, cylinders, or knife or brush type geometries.

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17. The apparatus according to claim 15 or 16 where one or both of said electrodes is segmented in different parts of any shape.

10 18. The apparatus according to any one of claims 15 to 17, comprising a parallel and/or serial combination of one or more of said electrodes.

15 19. The apparatus according to any one of claims 15 to 18, where one or both electrodes are temperature controlled.

20. The apparatus according to any one of claims 15 to 19, where one or both of the electrodes is movable.